INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 11, No. 6, p. 58-65, 2017

RESEARCH PAPER OPEN ACCESS

Exploring Allelopathic potential of carrot weed (*Parthenium hysterophorus* L.) on germination and early growth of maize (*Zea mays* L.)

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Article published on December 30, 2017

Key words: Allelopathy, Bioherbicides, Maize, Parthenium

Abstract

Studies were carried out to scrutinize allelopathic potential of aqueous extracts of *Parthenium hysterophorus* L. on germination and growth of maize crop. Seed germination, seedling growth and biomass production was also examined. Distilled water was use as a control treatment. Completely randomized design (CRD) was used along with five treatments and three replications. Results revealed that there is significant difference among treatments applied. All extracts of *Parthenium* stimulate germination of maize when compared with control. Among the treatments applied seed treatment has very pronounced result on germination percentage, germination index, and mean germination time and germination energy. Whereas seedling parameters are positively affected by application of root extracts except for seedling vigor index and shoot dry weight. However, Shoot extracts has also encouraging outcomes on emergence energy and emergence percentage. It was suggested that further experimentation was needed to explore the stimulatory role of *Parthenium* on maize so that this weed can be used as bioherbicide.

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Introduction

The term "allelopathy" was used to describe the effect of one plant on other plant. It is also coined to illustrate all the biochemical interactions (stimulatory and inhibitory) among the plants. Allelopathic effects may be form of crop on weed, or crop on crop or weed on crop or weed on weed (Stamp 2003). Allelochemicals which hamper the growth of plant at definite application may motivate growth of similar or other species at other concentration (Rao, 2000).

Parthenium hysterophorus L. also known as congress grass is an annual persistent weed, belongs to family Asteraceae. North and South America is a country where it is first originated and is now establish in all other parts of globe (Navie *et al*., 1996). 10℃ to 25℃ is optimum temperature for its germination (Tamado, 2002) and able to completes three generations in a year (Dhawan. 1996) and 10,000 to 15,000 viable seeds are produced by a single plant thus can disperse and sprout to swarm large vicinity (Singh *et al*., 2008). The escalation inhibitors are unconfined by leakage, exudation of roots during decompose and from plant residues and deposit in soil thus affects growth of coming plant species (Picman and Picman, 1984). Marwat *et al*., (2008) found that wheat seed germination percentage is slightly inhibited by *Parthenium* extracts concentration while extent of hinderness depends upon origin of *Parthenium*.

Mubeen *et al*., (2011) reported that root extracts of *T. portulacastrum* delayed MGT and T50 in rice seeds. It became complex issue to human beings all over the world due to its wide spread and attains seven positions in world's worst and devastating weeds (Patel, 2011). This weed is promptly scattering in various parts of Punjab and Khyber pakhtunkhwa and Kashmir and replacing native vegetation (Javaid and Anjum, 2006; Javaid *et al*., 2010). Some herbicides are very effective in eradicating this weed (Javaid. 2007) but that may cause different health problems to human beings, biodiversity and the environment (Rashid *et al*., 2008). Allelochemicals are plant derivative chemicals having a tremendous ability to utilize as bio-weedicides relatively safer for surroundings.

Therefore, much work has been done to control weeds by plant derived chemicals in last few decades (An *et al*., 1998). Allelopathic efficiency of weed on growth and development of crops vary from weed to weed and crop to crop (Hamayun *et al*., 2005). The allelopathic effects of various parts of same weed differ in their effects on different growth stages of crop (Aziz *et al*., 2008; Economou *et al*., 2002). The information available on allelopathic potential of *Parthenium* on maize crop is scant; consequently the current study was intended having aim;

To evaluate the effect of aqueous extracts of different parts of *P. hysterophorus* L. on germination and early growth of maize.

Materials and methods

The current experiment was anticipated to appraise the allelopathic potential of *Parthenium* on germination and early growth of maize. Completely Randomized Design (CRD) was laid out along with five treatments and three replications. at Research Laboratory of Agronomy, University of AJ & K, Faculty of Agriculture, and Rawalakot during 2013. Germination trail was conducted in petri dishes in laboratory whereas soil culture was used to conclude results for seedling growth

Collection and extraction process of Parthenium plant parts

At maturity *Parthenium* plants were taken from open fields and after few days of shade drying, these were cut in small pieces and different plant parts were separated as roots, shoots and seeds and kept some plants as a whole for further making extracts of different parts and use them in experiment. Shade dried plants were put in oven at 60℃ for twenty four hours. The oven desiccated herbage of *Parthenium* was ground in chopper (grinder) and filtrate was obtained after sieving. The filtrate thus obtained was soaked in distilled water (1:20W/V) for twenty four hours at room temperature (Hussain and Gadoon, 1981) to obtained aqueous extracts of different plant parts of *Parthenium*. The extract attained was filter using filter paper to separate impurities and refined extracts thus obtain would be used in experiments as per treatment as fresh aqueous extracts (Rashid *et al*., 2008).

Experiment No. 1

First part consists of exploring allelopathic effects of *Parthenium* on germination of maize. Filter paper was used as a medium of germination in petri dishes for use of different treatments. All petri dishes were kept in incubator at 25℃. Each petri dish contained five maize seeds. Different parts of aqueous extracts of parthenium were applied in petri dishes. Distilled water was also used as a control treatment. Petri dishes were examined regularly and extracts along with distilled water was subsequently applied to avoid drying of filter paper during experiment. Following parameters were measured:

- Germination percentage
- Germination index
- Mean germination time
- Time taken to 50% germination (T50)
- Germination energy

Germination percentage and T50

The experiment was examined daily and germination percentage was calculated by counting germinated seeds according to formula given by Association of Official Seed Analyst (1990).Time taken to reach 50% germination was calculated by technique proposed by Coolbear *et al.*, 1984) and modified by Farooq (2004).

$T50=ti + (N/2-ni) (tj-ti)/(nj- ni)$

Where N is the final/actual number of seeds germinated while nj and ni are the cumulative number of seeds germinated by adjacent counts at time tj and ti respectively.

Germination index and Mean germination time

Germination index (%) was calculated by using formula=

$$\frac{\text{No. of germinated seeds}}{\text{Days to First count}} +\_+ \frac{\text{No. of germinated seeds}}{\text{Days to First count}}$$

$$MGT = \frac{\sum Dn}{\sum n}$$

While n is number of seeds germinated on day D whereas D is number of days counted from beginning of experiment.

Germination energy

Germination energy (percentage of germinated seeds at fourth day comparative to number of seed to be tested) was observed on daily basis however at fourth day after start of experiment final data was recorded.

Experiment No. 2

Second part of experiment was designed to explore potential effects of *Parthenium* on early growth of maize crop. Ten seeds per pot (filled with soil) were sown and thinning was done after germination. Extracts prepared by different parts of *Parthenium* and distilled water was frequent added to pots as per treatments. Following parameters were measured:

1. Emergence energy
2. Emergence percentage
3. Root length (cm)
4. Shoot length(cm)
5. Mean emergence time
6. Seedling vigor index
7. Root fresh weight (g)
8. Root dry weight (g)
9. Shoot fresh weight (g)
10. Shoot dry weight (g)

Root and shoot length and SVI

Seedling growth (root and shoot length) was recorded at the end of experiment. Maize plants were uprooted, washed shade dried for two days. Shade dried plants were placed in an oven at 60℃ for three days to get constant weight of seedlings of maize. SVI (Seedling Vigor Index) was calculated by using formula;

SVI= Germination/Emergence percentage* radical length Data recorded on above parameter was analyzed by using Fisher's Analysis. LSD at 5% probability was used to compare values.

Results and discussion

Before using *Parthenium* for planned experiment, some of biochemical parameters were tested in order to understand its effect on maize. Results of those parameters were presented in Table 1.

Table 1. Biochemical Analysis of *Parthenium hysterophorous* L. Biochemical analysis of *Parthenium* are presented in Table 1 includes

Treatments	pH		EC (ms/cm)		TPC (mg/g of garlic acid)		TDS (g)	
	Fresh	Old	Fresh	Old	Fresh	Old	Fresh	Old
RtE	5.6	7.91	2.91	7.1	170.2	197.8	0.11	0.04
ShE	6.6	7.84	3.3	6.7	219.7	222	0.11	0.09
WpE	6.4	6.8	3.69	6.2	222	223.1	0.17	0.09
SdE	6.0	7.7	5.59	6.5	224.3	223.1	0.23	0.17

RtE= Root Extract; ShE= Shoot Extract; WpE= Whole Plant Extract; SdE= Seed Extract.

EC= Electrical Conductivity; TPC= Total Phenolic Contents; TDS= Total Dissolve Solids.

- ph
- EC (ms/cm)
- TPS (mg/g of garlic acid)
- TDS (g)

Germination Parameters

First part of experiment was conducted to measure germination percentage, germination index, mean germination time, time taken to 50% germination and germination energy.

Exposure of different extracts (treatments) of *Parthenium* revealed that the seed extract of *Parthenium* showed maximum germination percentage (89.3%) which indicates that more stimulatory effect on the germination percentage of maize while distilled water had the minimum values (53.56%). Germination enhancement was might be due to the presence of vanillic acid (stimulating agent in *Parthenium,* Towers *et al*., 1997). While whole plant, shoot and root extract also significantly differ from each other and having values 75.82, 62.62 and 58.78 respectively. Root extracts had minimum germination among the extracts applied. Findings were aline with investigations of Rashid *et al*., (2008) that delineated that *Parthenium* weed root extract slightly inhibit maize seed germination. Inhibition was more pronounced with increasing concentrations of root extracts. Similar results investigated by findings of Marwat *et al*., (2008) who found germination percentage of wheat seed was slightly inhibited by *Parthenium* extracts. While inhibition was depend upon origin of *Parthenium*.

Data recorded to measure germination index depicted that seed extract (39.28) and whole plant extracts (37.40) had the highest value over the control (31.05). While by applying the aqueous extracts of root and shoot (29.63 and 27.68) showed the inhibitory effect on germination index of maize (Table 2).

Einhelling (1995) found that allelopathic inhibition was due to combination of allelochemicals that would interfere with different physiological processes. Different scholars reported that different parts of *Parthenium* showed different response towards inhibition. This was due to variation in composition of sesquiterpene lactones (Picman and Towers 1982). While aqueous extracts of seeds of *Parthenium* had the highest inhibitory effect (6.66) on the MGT of the maize among all the treatments applied and distilled water had least value (6.10) whereas shoot, whole plant and root extracts showed the intermediate values (Table 2). Results are supported by findings of Babar *et al*., (2009) who explored that seed soaked in aqueous extract of *A. tenulifolius* Cav. took more time for mean germination time.

However, germination energy of maize by applying seed extract had the highest value (70.67) among all the treatments applied which indicate that seed extract might have more stimulatory effect due to the presence of vanillic acid (stimulating agent in *Parthenium*) (Towers *et al*.,1977). While germination energy of whole plant extracts, root extract and shoot extracts have 75.82, 51.65 and 46.22 values. Distilled water and root extracts do not have significant difference between them (Table 2). However, by applying the aqueous extracts of shoot have inhibitory effects on germination energy. This inhibitory effect might be due to present of p-caumaric and caffiec acid (Narwal, 1994). The experiment clearly indicates that by applying aqueous extracts of seed significant increase in germination energy (Table 2).

Table 2. Effect of aqueous extracts of different parts of carrot weeds *(Parthenium hysterophorous* L.*)* on the germination of maize *(Zea mays* L*).*

Parameters / Treatments	Germination %	Germination Index	Mean Germination Time	Time taken to 50% germination	Germination Energy
E1	53.56 e	31.05 b	6.10 d	1.61 b	51.41 c
E2	58.78d	29.63 bc	6.22 cd	1.77 a	51.65 c
E3	62.62 c	27.68 c	6.52 b	1.44 d	46.22 d
E4	75.82 b	37.40 a	6.34 c	1./45 d	75.82 b
E5	89.63 a	39.28 a	6.66 a	1.53 c	70.67 a

E_1=Distilled water, E_2=Root Extract, E_3=Shoot Extract, E_4=Whole Plant Extract, E_5=Seed Extract.

Emergence Parameters

Emergence energy and emergence percentage

Exposure of maize to aqueous extracts of root and shoot showed highest emergence energy (33.29 and 32.92) among all the treatments applied while distilled water showed minimum emergence energy (13.30). There is no significant difference between whole plant and seed extracts (25.18 and 26.71) when compared with each other but significant differences are present when compared with all other treatments. Current findings were against with investigations of Muchlchen *et al*., (1990) who found that germination and emergence was condensed due to potential effects of Asteraceae family on small grain crops. These contradictory outcomes are due to temperature not optimum for maize germination and emergence.

While aqueous extracts of shoot and root showed the maximum value of emergence percentage which are 40.66% and 40.00 % respectively which may be owing to the stimulatory effect of both these extract on the emergence percentage, while whole plant extract (32.44%) and seed extract (26.71%) also showed marked variation. On the other hand, distilled water had the minimum values (13.40%). It was interesting to observe that all the extract promoted the emergence of maize seedlings over distilled water as a control. These stimulatory effects might be due to presence of allelochemicals in maize and both types of allelochemicals present in *Parthenium* and maize synergistically act with each other to enhance the germination emergence of maize crop.

Root length and shoot length (cm)

The aqueous treatments of *Parthenium* to maize seedlings exhibited significance difference with marked variation in root length. Exposure of maize seedlings to root extracts revealed increased root growth with significantly lengthy roots (20.20cm) among all treatments applied. it was noteworthy that increase in root length as a result of application of root extract of *Parthenium* showed stimulatory effect over the control treatment. It could be owing to stimulatory allelochemicals in the root extract. Seed extract of the subject weed revealed significant difference from the rest of treatments except of the whole plant (6.06cm). The allelochemicals in the whole plant extract might have been diluted over the given volume of the extracts. It was also interesting to observe that the root length increased by the application of all extracts when compared with distilled water as a control (1.06cm).

Present studies have disagreement with the findings of Teferea, (2002). These contrary consequences are might be in difference of crops chosen.

Exposure of aqueous extract of *Parthenium* to maize shoot showed that applying aqueous extracts of root produced maximum shoot length (25.97) which could be due to the stimulatory effects on maize shoot growth. While by applying aqueous extracts of whole plant and seed, the variation in shoot length was non- significant (12.74) and (11.73) while distilled water had the least length of shoot of maize seedlings (Table 3). Results are supported by findings of Mubeen *et al*., (2012) that came up with conclusion that application of sorghum, sunflower alone and in combination improves shoot length of rice over control might have been because of stimulatory allelochemicals in these extracts.

Likewise, exposure of the aqueous extracts of *Parthenium* on the mean emergence time (MET) of the maize revealed that by applying aqueous extract of root showed highest value (7.92) of MET while by applying the aqueous extracts of shoot (5.12) and seed (5.05) didn`t show marked variation while distilled water had the least value (2.51).

Table 3. Effect of aqueous extracts of different parts of carrot weed *(Parthenium hysterophorous* L.*)* on the seedling growth of maize *(Zea mays* L.*)*.

Parameters / Treatments	Emergence Energy	E%	Root length	Shoot length	Mean Emergence Time	Seedling Vigor Index	Root Fresh weight	Root Dry Weight	Shoot Fresh Weight	Shoot Dry Weight
E1	13.30c	13.40d	1.06d	2.82d	2.51c	1723.3 a	0.118c	0.07a	0.0700b	0.14ab
E2	33.29a	40.00a	20.20a	25.97a	7.92a	801.55 b	1.050a	0.32a	0.5833 a	0.11bc
E3	32.92a	40.66a	7.21b	9.69c	5.12b	528.55 c	0.4667b	0.24b	0.1867ab	0.13ab
E4	25.18b	32.44b	6.06c	12.74b	5.14b	296.44d	0.75a	0.18c	0.2500ab	0.09c
E5	26.71b	26.71b	6.44c	11.73b	5.05b	222.22 c	0.3367bc	0.15c	0.20ab	0.15a
LSD	3.473	4.062	0.516	1.180	0.768	62.453	0.3521	0.0467	0.41	0.0329

E1=Distilled Water**;** E2=Root Extract**;** E3=Shoot Extract; E4=Whole Plant Extract; E5=Seed Extract.

Seedling vigor index

The application of aqueous extracts of different part of *Parthenium* to maize seedlings exhibited significance difference with marked variation in SVI. Exposure of maize seedlings to distilled water showed amplified SVI (1723.3) when compared with other treatment tested discovered that extracts of different part of *Parthenium* has inhibitory effects on SVI while by applying seed extracts of *Parthenium* showed the least SVI (222.22). Results are supported by findings of Mubeen *et al.*, (2012) who reported maximum SVI of weeds were found (*Dactyloctenium aegyptium*, *Elusine indica* and *Trianthema portulacastrum*) where distilled water was used as treatment.

Root and shoot dry weight (g)

Parthenium exhibited significance differences with marked variation in root fresh and dry weight per seeding. Exposure of maize seedling to distilled water showed maximum root dry weight per seedlings (0.35) while by applying whole plant extract and seed extract showed minimum value of root dry weight having (0.18) and (0.15) respectively. Application of the extracts of whole plant and seed showed statistically similar results but significantly different from distilled water, root and shoot extracts. Mubeen *et al.*, (2011) found that water extracts (different treatments) of weeds studied showed significantly for root dry weight of rice. Whereas the application of aqueous extracts of different part of *Parthenium* to maize shoot dry weight exhibited marked variation. Shoot dry weight was greatest when seed extract was applied (0.15) and smallest when whole plant extract was applied (0.09). While by application of distilled water and shoot extract showed non-significant differences between them but significantly differed from root, whole plant and seed extracts application. Chou and Lee (1991) found aqueous extracts of *Miscanthus tranmorrisonensis* enhanced germination and radical growth of rye grass (*Lolium perenne* L.).

Conclusion

Different parts of *Parthenium* have different potential to enhance growth of crop under studied. *Parthenium* extracts can boost germination and growth of maize crop however, its stimulatory effect is depending upon its optimum concentration and as well as plant parts which is used for making extracts. Further experimentation need to assess the exact and optimum concentration along with different parts of *Parthenium* so to use it as bioherbicide.

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